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SUMMARY OF DRILLING PROJECT FOR ADDITIONAL RECOVERY WELLS WHITMOYER LABORATORIES, MYERSTOWN, PENNSYLVANIA

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AR100082

SUMMARY OF DRILLING PROJECT FOR ADDITIONAL RECOVERY WELLS WHITMOYER LABORATORIES, MYERSTOWN, PENNSYLVANIA

Our report entitled, *The Recovery of Waste Chemicals by Means of Wells at the Whitmoyer Laboratories, Myerstown, Pa.*, submitted in March 1966, outlined the need for enlarging the pattern of wells in use at that time for recovering waste chemicals that have contaminated the ground-water resources of the area. Subsequently, a number of well sites were selected and the first of the new wells was drilled in mid-August 1966.

In all, 23 wells were drilled on the Whitmoyer, Grumbine, and Winthrop properties during the period August-December 1966. (See accompanying map.) All drilling was done by the air-percussion rotary method by Kohl Brothers, Inc. of Myerstown, Pa. The wells were cased with 6-inch pipe, set firmly into the top of the limestone bedrock. An uncased hole with a diameter of 5-7/8 inches was drilled below the bottom of the casing to a depth prescribed by the consultant at the site. During drilling the yield was measured volumetrically at frequent intervals and water samples were collected at different depths for arsenic determinations. The arsenic analyses were made by the Whitmoyer laboratory.

The geologic and hydrologic data obtained from the drilling of each well are given in Table 1 (at the end of this report). The yields and arsenic concentrations listed for the wells relate to conditions during, or at the end of drilling, and can be expected to change somewhat when the wells are pumped on a continuous basis. In general, both the yield and the arsenic concentration will show declining trends soon after pumping begins.

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RECOMMENDED USE OF THE NEW WELLS

The March 1966 report included recommendations for drilling an encircling pattern of wells that under ideal conditions would serve as a "drawdown trough" beyond which it would not be hydraulically possible for the contaminated water to flow. It was recognized of course that some of the recommended well sites perhaps would not be productive and that substitute sites would be required. This eventuality was borne out by the drilling program. As indicated by the data for yields and arsenic concentrations given in Table 1, some of the test wells are unsuitable for the recovery of arsenic or for observation purposes. These have either been filled in or should be sealed as soon as practicable.

The drilling data for the various wells have been evaluated with respect to their locations, yields, and arsenic concentrations. Table 2 (on the following page) lists those wells which are recommended for use as production wells, and lists the yield and arsenic concentration that were measured in each of the wells when drilling was completed. These wells are shown on the accompanying map by appropriate symbol.

Based on the initial operating experience in 1964 with the existing system of recovery wells (Wells 1-7), it is probable that the total rate of withdrawal of the wells shown in Table 2 would soon decline to perhaps one-half the initial rate, particularly if part of the water pumped should be disposed of as recommended later in this report. Thus, the combined yield of the new wells might be on the order of 200-250 gpm (gallons per minute) initially and then more or less level off to ±100 gpm.

TABLE 2

SUMMARY DATA FOR PROPOSED PRODUCTION WELLS

Well No.	Depth (ft)	Yield at completion of drilling (gpm)	Arsenic concentration at completion of drilling (ppm)
5-A	158	9.5	326
9	97	40	155
9-A	100	50	102
10-A	98	26	440
11	98	12	349
15-A	60 a/	16 a/	33 a/
16-B	120	10	146
17	70	80	297

a/ Additional work required to clean well may change indicated data.

The recommended pattern of new production wells and the continued operation of existing wells is believed to be the best configuration for preventing the further escape of arsenic-bearing water from the plant site. It is recognized that the encirclement of the plant by overlapping cones of depression will not be complete with the well pattern that has resulted from the drilling program, but it is believed that most of the contaminated water that is presently escaping will be captured by the new wells.

In recognition of the need for observing and evaluating the results of an expanded pattern of recovery wells, provisions were made for a number of observation wells suitable for making peripdic water-level measurements and monitoring changes in the arsenic content of the water in the wells. Table 3 (on the following page) lists the new wells that are recommended for use for observation purposes. The yield and arsenic concentration measured in each of these wells when drilling was completed are shown in the table.

GENERAL EVALUATION OF NEW WELLS

Early in the present investigation, it was recognized that highly concentrated water occurs predominantly in two directions from the original disposal sites: the lowland to the north, extending north of Tulpehocken Creek at least to the Grumbine residence; and the creek valley to the east for an undetermined distance. Therefore, extension of the recovery well system into these two lowland areas is of primary importance and it is believed that the new wells will accomplish this objective. Wells 16R and 17, with an estimated long-term combined yield of ±40 gpm,

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TABLE 3

SUMMARY DATA FOR PROPOSED OBSERVATION WELLS

Well No.	Depth (ft)	Drilling yield (gpm)	Arsenic concentration (ppm)
8-B	100	Essentially dry	52
10-B	56	13	201
11-A	36	12	102
12	118	1	2.1
12-A	98	0.7	6.6
13	138	2	20
13-A	190	1	104
16	118	4	116
16-A	77	1.2	44
17-A	60	12	37

are located so as to intercept shallow ground-water flowing eastward from the plant. Analyses of samples taken when these and adjacent wells were drilled clearly indicate the need for ground-water recovery in this direction.

Four new wells, Wells 9, 9-A, 10-A, and 11, will probably have a combined long-term yield of 50-60 gpm, and it is believed that their location and spacing will be effective in correcting ground-water escape northward from the former disposal areas.

Four of the new wells, Wells 12, 12-A, 13, and 13-A, resulted in yields too low for use of the wells as production wells and as a result, the protection afforded by the recovery well system is somewhat less than satisfactory in the west and southwest directions. However, long-term sampling data for wells and surface seeps to the west and southwest indicate low arsenic concentrations. Future observation of water-level trends and arsenic concentration in Wells 12, 12-A, 13, and 13-A will indicate whether a new production well in the southwest part of the Whitmoyer property is actually needed. It may be found desirable to pump these low-yielding wells at some later time to make sure that the relatively low arsenic content in this direction is known with certainty.

Wells 13, 14, 15, and 15-A were drilled along the southern boundary of the Whitmoyer property. Of these, only Well 15-A yielded enough water to be useful as a production well. However, this well encountered a mud-filled cavity from 53-57 feet and it appears that further work will be required before it can be used as a dependable production well. Before a drilling rig is brought in for cleaning out the cavity and perhaps deepening the well, a test pump should be installed to determine if the well can

be utilized in its present condition. Perhaps Well 15-A will be ineffective in intercepting the movement of contaminated water to the south and southeast, but in view of the low concentration of arsenic in the ground water in these directions, it is recommended that no additional drilling be undertaken along the southern boundary unless observations at monitor Wells R-5, R-6, and at Miller Machine, Inc. indicate the situation is not improving.

Reference is made here, as in the past, to the desirability of allowing the combined cone of depression to enlarge to the greatest extent possible, if the primary objective of the recovery program is to prevent the escape of arsenic-bearing water. Obviously, even though additional water may soon be pumped from the contaminated aquifer, there will be essentially no net growth of the general cone of depression if the treated water is lagooned and returned to the ground. For this reason, it will be desirable to either decant the clear lagoon water to the creek to the greatest extent practicable, or pump the water from the lower arsenic-content wells directly into the creek for dilution to an acceptable level. In this way, the combined cone of depression will enlarge, the yield of the wells will decline, and the containment of arsenic in the locality will be maximum.

It is recommended that each well be pumped continuously at its maximum rate. At the time the wells were drilled, it was not practicable to make pumping tests of the wells suitable for properly determining the yield-drawdown relationship, and thereby calculate the appropriate size and setting for a pump. However, our best judgment as to the size of the pump and the depth at which the pump should be set is indicated in Table 4 (on the following page).

TABLE 4

SUGGESTED PUMP CAPACITIES AND SETTINGS

Well No.	Proposed pump capacity (gpm)	Proposed pump setting (feet below land surface)
5-A	15 a/	109 a/
9	25	90
9-A	25	90
10-A	20	90
11	10	90
15-A	15 b/	50 b/
16-B	10	115
17	50	65

a/ Pump presently in use.

b/ Temporary capacity and setting until effectiveness of well cleaning is known.

At least two of the observation wells should be equipped with recording water-level gages. Weekly water levels and arsenic determinations for all observation wells should be graphically plotted for the first few months after the new wells start operating. Thereafter, a less frequent measurement schedule should be adequate.

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January 1967

TABLE 1 (5-A)

RECORD OF WELLS

Site 5-A

Whitmoyer Property

Completion Data:

Depth - 158 feet, Yield - 9.5 gpm, As - 326 ppm
Drilling started 4:30 p.m. 8/24/66, completed 5:45 p.m. 8/26/66
Average drilling speed - 11 feet/hour
Casing - 13.5 feet of 6-inch

Geologic Log:

0 -	2	Limestone, weathered, with some soil
2 -	10	Limestone, buff, soft
10 -	23	Limestone, dolomitic, light gray to buff; clay seam 14-15 feet
23 -	28	Limestone, broken and mud, brown
28 -	36	Limestone, dolomitic, medium gray
36 -	158	Limestone, dolomitic, medium to dark gray

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
45	7	275
65	6.5	275
97	9.5	358
97	9.5	274
147	9.5	326

Remarks:

The broken zone at 23-28 feet was directly connected to Well 5, 17 feet to the east, to the extent that air from the drilling rig was blowing out of the top of Well 5. The production of Well 5 became so muddy that it had to be taken out of service. By sounding, Well 5 was found to be filled in to about the level of the pump intake (21 feet). Well 5-A produced about 6-7 gpm from the broken zone at 23-28 feet. The yield increased to 9.5 gpm between 80 and 90 feet. Drilling was stopped at 97 feet while an attempt was made to clean the mud from the 23-28 foot zone. After almost a day of cleaning, drilling was resumed and the well was completed to 158 feet with no additional water being encountered.

The pump from Well 5 was installed in 5-A and production began in September.

TABLE 1

RECORD OF WELLS (Continued)

Site 8

Grumbine Property

Completion Data:

Depth - 98 feet, Yield - 1 gpm, As - 118 ppm
Drilling started 7:30 a.m. 12/5/66, completed 11:50 a.m. 12/5/66
Average drilling speed - 22.5 feet/hour
Casing - 10.5 feet of 6-inch

Geologic Log:

0 - 9	Soil, clay and sand, brown
9 - 15	Limestone, medium gray, with water-bearing clay seams at 12 and 14½ feet
15 - 95	Limestone, dolomitic, medium to dark gray
95 - 98	Limestone, dolomitic, light to medium gray

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
57	1	84
98	1	118

Remarks:

The clay zones at 12 and 14½ feet were gradually cleaned out to contribute the measured yield.

The yield of this well is insufficient for a production well and it is not needed as an observation well.

TABLE 1 (8-A)

RECORD OF WELLS (Continued)

Site 8-A

Grumbine Property

Completion Data:

Depth - 118 feet, Yield - less than ½ gpm, As - trace
Drilling started 12:15 p.m. 12/5/66, completed 8:10 a.m. 12/6/66
Average drilling speed - 19.5 feet/hour
Casing - 17.5 feet of 6-inch

Geologic Log:

0	- 11	Soil, clay and sand, brown
11	- 17	Limestone, gray, with thin mud streaks
17	- 118	Limestone, gray, mud-filled fracture at 31 feet

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
98	0.5*	Trace

* - Startup

Remarks:

This well is located about 75 feet south of Site 8. Water production, in form of brown mud, began at about 8 feet. At no time was enough water produced to wash out the mud seams. After standing overnight at depth of 98 feet, enough water for a sample was produced on startup.

The yield of this well is insufficient for a production well. Mud will probably slump into the borehole, making it a poor observation well.

TABLE 1 (8-B)

RECORD OF WELLS (Continued)

Site 8-B

Whitmoyer Property

Completion Data:

Depth - 100 feet, Yield - essentially dry, As - 52 ppm
Drilling started - 2:15 p.m. 12/9/66, completed 4:15 p.m. 12/14/66
Average drilling speed - 10.5 feet/hour
Casing - 34 feet of 6-inch

Geologic Log:

0 - 15	Soil and clay, brown, with stones
15 - 100	Limestone, dolomitic, light to medium gray, fracture zone at 25 feet, lost circulation at 28 feet, fracture at 66 feet

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
20	3	42
28	18	52

Remarks:

This well is located about 150 feet southwest of Well 8. About 3 gpm was encountered at 20 feet and for a short time 18 gpm was produced from the fracture zone at 25 feet. Circulation was lost at 28 feet, presumably into the 25-foot zone. It was necessary to ream the well and set casing past this zone. After setting 34 feet of casing, drilling proceeded to a depth of 100 feet, producing barely enough water to wet the drill cuttings.

A production well might be salvaged at this site by pulling the casing back to expose the 25-foot fracture zone and removing the cuttings from this depth. However, the surrounding wells are good and should provide coverage in this area. For the present it appears that retaining this well as an observation and sampling well is advisable.

TABLE 1

RECORD OF WELLS (Continued)

Site 9

Grumbine Property

Completion Data:

Depth - 97 feet, Yield - 40 gpm, As - 155 ppm
Drilling started 12:15 p.m. 8/30/66, completed 2:45 p.m. 8/31/66
Average drilling speed - 9.5 feet/hour
Casing - 9 feet of 6-inch, slotted 5.8 to 8.8 feet

Geologic Log:

0 - 8	Soil and clay, brown, with stones
8 - 23	Limestone, dolomitic, light to medium gray
23 - 24	Limestone, soft, black
24 - 97	Limestone, dolomitic, medium to dark gray, water- and mud-bearing opening at 78-79 feet

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
11	Not determined	191
23	20	190
79	60	151
97	40	155

Remarks:

The first water was encountered at 8 feet. The yield gradually increased to 20 gpm in the 20-40-foot interval. The 78-79-foot zone, the only recognizable water-bearing fracture in the well, increased the yield initially to 60 gpm but with prolonged pumping the yield fell to 40 gpm. The pumping at Site 9 caused measurable interference at C-2, C-1, A-15, and A-16.

The yield and analyses indicate that this will be a useful production well.

TABLE 1 (9-A)

RECORD OF WELLS (Continued)

Site 9-A

Grumbine Property

Completion Data:

Depth - 100 feet, Yield - 50 gpm, As - 102 ppm
Drilling started 4:15 p.m. 12/8/66, completed 1:15 p.m. 12/9/66
Average drilling speed - 15 feet/hour
Casing - 12 feet of 6-inch

Geologic Log:

0	- 10.5	Soil and clay, with sand, brown
10.5	- 100	Limestone, dolomitic, light to medium gray, water-bearing fracture at 38 feet, weathered fracture zones with water at 41-42 feet and 53 feet

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
44	27	172
58	40	100
80	45	84
100	50	102

Remarks:

The fracture zones noted in the log brought the yield to 40 gpm. The additional 10 gpm probably resulted from self-development by pumping. Pumping this well during drilling produced measurable interference at Sites 9, 10 and 10-A.

The yield and analyses indicate that this well will be a useful production well.

TABLE 1

RECORD OF WELLS (Continued)

Site 10

Grumbine Property

Completion Data:

Depth - 110 feet, Yield - 2 gpm, As - 124 ppm
Drilling started 3:30 p.m. 8/31/66, completed 11:30 a.m. 9/2/66
Average drilling speed - unknown, too many breakdowns
Casing 8.5 feet of 6-inch, slotted 5.2 to 8.3 feet

Geologic Log:

0 - 7	Soil, clay, brown, with stones
7 - 8	Boulder
8 - 52	Limestone, dolomitic, medium to dark gray
52 - 55	Limestone, dolomitic, medium gray, with clay seams
55 -110	Limestone, dolomitic, medium to dark gray

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
26	0.5	14.6
61	2	106
98	2	95
110	2	124
110	4	20

Remarks:

The yield was barely measurable until the 52-55-foot zone brought the production up to 2 gpm. After the casing was slotted the yield increased to 4 gpm from shallow water but the concentration dropped to 20 ppm As. Slotting the pipe permitted shallow mud to fill the hole to a depth of about 20 feet by December.

The well had insufficient yield for a production well. In its present condition it serves no useful purpose.

RECORD OF WELLS (Continued)

Site 10-A

Grumbine Property

Completion Data:

Depth - 98 feet, Yield - 26 gpm, As - 440 ppm
Drilling started 12:35 p.m. 9/2/66, completed 9/6/66
Average drilling speed - unknown
Casing - 12.5 feet of 6-inch, slotted 9.2 to 12.2 feet

Geologic Log:

0 - 11	Soil, clay, brown, with stones
11 - 98	Limestone, dolomitic, medium to dark gray

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
26	0.2	8.6
40	0.5	29
48	4	540
52	12	1050
98	35	520
98	26	440

Remarks:

This well is located about 95 feet west of Site 10. The yield of this well gradually increased as small and relatively clean fractures were encountered.

The yield and analyses indicate that this will be a useful production well.

TABLE 1 (10-B)

RECORD OF WELLS (Continued)

Site 10-B

Grumbine Property

Completion Data:

Depth - 56 feet, Yield - 13 gpm, As - 201 ppm
Drilling started 8:45 a.m. 12/6/66, completed 11:20 a.m. 12/6/66
Average drilling speed - 22 feet/hour
Casing - 10.5 feet of 6-inch

Geologic Log:

0 - 4	Soil and clay, with sand, brown, with boulders
4 - 9	Limestone, dolomitic, light to medium gray
9 - 17	Limestone, dolomitic, dark gray, thin fracture at 10.5 feet and mud seam at 15 feet
17 - 56	Limestone, dolomitic, light to medium gray, fracture at 26 feet

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
36	18	194
56	13	201

Remarks:

This well is located about 100 feet north of Site 10. The major water-production zone was the fracture at 26 feet. The yield dropped from 18 to 13 gpm as pumping continued.

This well was located specifically for use as an observation well. The yield and analyses indicate that the well will serve this purpose.

TABLE 1

RECORD OF WELLS (Continued)

Site 11

Grumbine Property

Completion Data:

Depth - 98 feet, Yield - 12 gpm, As - 349 ppm
Drilling started 7:15 a.m. 8/29/66, completed 5:30 p.m. 8/29/66
Average drilling speed - 9.5 feet/hour
Casing - 13 feet of 6-inch, slotted 9.5 to 12.5 feet

Geologic Log:

0 - 8	Soil, clay and sand, brown, with stones
8 - 9	Boulder
9 - 12	Limestone, tan, weathered and broken
12 - 30	Limestone, dolomitic, medium to dark gray, water-bearing opening at 26 feet
30 - 33	Limestone, dolomitic, light gray
33 - 98	Limestone, dolomitic, medium to dark gray

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
20	10	334
30	13	326
98	12	349

Remarks:

The first water was encountered at 9 feet. Most of the yield was obtained in the 15-26-foot interval. Interference during drilling was observed at C-3, A-8 and possibly A-9.

The yield and analyses indicate that this will be a useful production well.

TABLE 1 (11-A)

RECORD OF WELLS (Continued)

Site 11-A

Grumbine Property

Completion Data:

Depth - 36 feet, Yield - 12 gpm, As - 102 ppm
Drilling started 6:45 a.m. 8/30/66, completed 10:30 a.m. 8/30/66

Average drilling speed - 9.5 feet/hour
Casing - 12.5 feet of 6-inch, slotted 9.3 to 12.3 feet

Geologic Log:

0	- 12.5	Soil and clay, brown, with stones
12.5	- 22	Limestone, dolomitic, light gray and tan, weathered and broken
22	- 36	Limestone, dolomitic, medium to dark gray

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
22	17	45
36	12	102

Remarks:

This well is located about 75 feet west of Site 11. The first water was encountered at 8 feet and most of the yield came from the 12-22-foot zone.

This well was drilled as an observation well and will be satisfactory for that purpose.

TABLE 1 (12)

RECORD OF WELLS (Continued)

Site 12

Whitmoyer Property

Completion Data:

Depth - 118 feet, Yield - 1 gpm, As - 2.1 ppm
Drilling started 8:30 a.m. 8/19/66, completed 11:20 a.m. 8/22/66
Average drilling speed - 8 feet/hour
Casing - 6.5 feet of 6-inch, slotted 3 to 6 feet

Geologic Log:

0	-	3.5	Soil and clay, brown, with stones
3.5	-	12	Limestone, dolomitic, light to medium gray
12	-	14	Limestone, soft, buff, water-bearing openings
14	-	118	Limestone, dolomitic, medium to dark gray

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
45	0.3	7.5
118	1	6.6

Remarks:

The soft zone at 12-14 feet produced about 0.3 gpm. Although there were no other observable production zones, the yield gradually increased to 0.7 gpm. After standing overnight the well produced a scant 1 gpm.

The yield and arsenic content are insufficient for a production well. The location of the well makes it desirable for a sampling and observation well.

TABLE 1 (12-A)

RECORD OF WELLS (Continued)

Site 12-A

Whitmoyer Property

Completion Data:

Depth - 98 feet, Yield - 0.7 gpm, As - 6.6 ppm
Drilling started 1:05 p.m. 8/22/66, completed 1:30 p.m. 8/23/66
Average drilling speed - 9 feet/hour
Casing - 6.5 feet of 6-inch, slotted 3.2 to 6.2 feet

Geologic Log:

0 - 4	Soil and clay, brown and stones
4 - 12	Limestone, dolomitic, light to medium gray
12 - 14	Limestone, light gray to buff, water-bearing opening
14 - 36	Limestone, dolomitic, light to medium gray, water-bearing opening at 20 feet
36 - 98	Limestone, dolomitic, medium to dark gray

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
98	0.7	6.6

Remarks:

Site 12-A is 110 feet east of Site 12. At a depth of 37 feet production was less than 1 pint per minute. After standing overnight the well produced 0.5 gpm and gradually increased to 0.7 gpm, although no observable openings were encountered.

The yield and arsenic content are insufficient for a production well. The position of the well is suitable for a sampling and observation well.

RECORD OF WELLS (Continued)

Site 13

Whitmoyer Property

Completion Data:

Depth - 138 feet, Yield - 2 gpm, As - 20 ppm
Drilling started 9:40 a.m. 8/16/66, completed 8:30 a.m. 8/17/66
Average drilling speed - 13 feet/hour
Casing - 8 feet of 6-inch, slotted 4.9 to 7.9 feet

Geologic Log:

0 - 4.3		Soil and clay, brown, with stones
4.3 - 38		Limestone, dolomitic, slightly weathered at top, mixed light and dark gray
38 - 138		Limestone, dolomitic, dark gray, water-bearing openings at 43, 52, and 76 feet

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)		As (ppm)
53	1	205, 318 *	±250
138	2		19.8
138	Bailed sample	Less than	10

Remarks:

Water production began at 52 feet at 1 gpm. The yield doubled at 76 feet but no further increases in production were attained.

The yield was insufficient and the arsenic content marginal for a production well. The well is useful as an observation and sampling site. There is evidence that pumping at Wells 1 and 2 causes interference at Site 13.

TABLE 1 (13-A)

RECORD OF WELLS (Continued)

Site 13-A

Whitmoyer Property

Completion Data:

Depth - 190 feet, Yield - 1 gpm, As - 104 ppm
Drilling started 10:15 a.m. 8/17/66, completed 6:00 p.m. 8/18/66
Average drilling speed - 9.5 feet/hour
Casing - 7 feet of 6-inch, slotted 3.8 to 6.8 feet

Geologic Log:

0 - 3.5		Soil and clay, brown, with stones
3.5 - 43		Limestone, dolomitic, light to medium gray.
43 - 190		Limestone, dolomitic, dark gray, water-bearing openings at 68, 84, and 127 feet

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
136	1	187
190	1	104

Remarks:

Site 13-A is 115 feet north of Site 13. Water production began at 84 feet at less than 1 quart per minute. At 127 feet the yield increased to 1 gpm. No further yield increases were encountered.

The yield of this well is insufficient for a production well. Its location is suitable for a sampling and observation well. Strong interference between Wells 1 and 2 and this well have been observed.

TABLE 1

RECORD OF WELLS (Continued)

Site 14

Whitmoyer Property

Completion Data:

Depth - 132 feet, Yield - essentially dry, As - 27 ppm (bailed sample)

Drilling started 2:35 p.m. 8/23/66, completed 3:25 p.m. 8/24/66

Average drilling speed - 10 feet/hour
Casing - 12.5 feet of 6-inch

Geologic Log:

0	-	1.5	Soil and clay, brown, with stones
1.5	-	10	Sand, fine; and limestone, highly weathered
10	-	22	Limestone, buff to light gray
22	-	24	Limestone, buff, soft
24	-	132	Limestone, dolomitic, medium to dark gray

Conditions Observed During Drilling:

Depth (ft)	As (ppm)	
132	27	(Bailed sample)

Remarks:

Only a few traces of moisture were encountered during drilling but there was enough seepage to obtain a bailed sample by August 29.

Although this site would have been favorable for an observation well, the walls of the hole caved in, filling the hole to a depth above the static water level.

TABLE 1

RECORD OF WELLS (Continued)

Site 15

Whitmoyer Property

Completion Data:

Depth - 97 feet, Yield - essentially dry, No analysis.
Drilling started 8:20 a.m. 8/15/66, completed 9:00 a.m. 8/16/66
Average drilling speed - 8 feet/hour
Casing - 20 feet of slotted 6-inch, removed upon completion

Geologic Log:

0 - 8	Soil and clay, brown, with stones
8 - 97	Limestone, dolomitic, dark gray, with some lighter streaks; dry clay zone at 14 and 17 feet; water-bearing openings at 29, 40, 45, and 74 feet

Remarks:

The water encountered in this well was barely enough to dampen the drill cuttings. Since this well yield was too small to result in a good observation well, the casing was removed and the hole was filled with cuttings.

TABLE 1 (15-A)

RECORD OF WELLS (Continued)

Site 15-A

Winthrop Property

Completion Data:

Depth - 60 feet, Yield - 16 gpm, As - 33 ppm
Drilling started 9:50 a.m. 12/15/66, completed 1:15 p.m. 12/15/66
Average drilling speed - 17 feet/hour
Casing - 13 feet of 6-inch casing

Geologic Log:

0	- 8.5	Soil and clay, brown
8.5	- 60	Limestone, dolomitic, medium gray, weathered fracture zones 18, 24, 37, 43, and 45 feet, open cavity with mud 53-57 feet

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
20	5	32
39	16	33

Remarks:

Each of the indicated fractures added measurably to the yield of this well. Circulation was lost in the 53-57-foot cavity and drilling was stopped because of the danger of getting the tools stuck. The location of this hole is ideal for a production site despite the comparatively low analyses. The hole should be cleaned and deepened, preferably by a cable-tool rig, perhaps followed by airlift pumping.

RECORD OF WELLS (Continued)

Site 16

Winthrop Property

Completion Data:

Depth - 118 feet, Yield - 4 gpm, As - 116 ppm
Drilling started 4:30 p.m. 12/6/66, completed noon 12/7/66
Average drilling speed - 21.5 feet/hour
Casing - 9 feet of 6-inch

Geologic Log:

0 - 6	Soil and clay; some sand; boulders
6 - 26	Limestone, dolomitic, light to medium gray, fracture at 16 feet
26 - 54	Limestone, dark gray; broken weathered zones with much calcite at 34-35 feet and 45 feet
54 - 118	Limestone, medium gray, with calcite seams, black limestone streak at 80 feet

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
18	2	170
45	3	38
78	4	41
118	4	116

Remarks:

Fracture at 16 feet yielded 2 gpm. At 45 feet the yield increased to 3 gpm. Apparently cleaning out of the 16-foot fracture raised the yield to 4 gpm.

Although the analyses are satisfactory, the long-term yield of this well appears to be too low for a production well. Its location is desirable for an observation and sampling well.

TABLE 1 (16-A)

RECORD OF WELLS (Continued)

Site 16-A

Winthrop Property

Completion Data:

Depth - 77 feet, Yield - 1.2 gpm, As - 44 ppm
Drilling started 12:20 p.m. 12/7/66, completed 4:50 p.m. 12/7/66
Average drilling speed - 17 feet/hour
Casing - 10.5 feet of 6-inch

Geologic Log:

0 - 7	Soil and clay, brown
7 - 21	Limestone, dolomitic, light to medium gray, fractures at 15-16 feet
21 - 30	Limestone, dolomitic, dark gray
30 - 77	Limestone, dolomitic, light to medium gray

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
22	2	30
77	1.2	44

Remarks:

The only recognizable zone contributing water to this well was the 15-16-foot fracture area.

The yield of this well is insufficient for a production well but the location is satisfactory for an observation and sampling site, the original purpose of this well.

RECORD OF WELLS (Continued)

Site 16-B

Winthrop Property

Completion Data:

Depth - 120 feet, Yield - 10 gpm, As - 146 ppm
Drilling started 7:15 a.m. 12/8/66, completed 12/17/66
Average drilling speed - unknown
Casing - 42 feet of 6-inch

Geologic Log:

0 - 10	Soil and clay, brown
10 - 37	Limestone, dolomitic, medium gray, fracture at 15 feet, weathered fracture zone at 30 feet, highly weathered fracture zone 35-37 feet
37 - 120	Limestone, dolomitic, medium to dark gray, with calcite seams, weathered fracture zone with mud at 51 feet

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
22	4.5	37
37	15	26
54	19	42
77	19	118
82	8	269
120	10	146

Remarks:

The first water was produced at 12 feet. At 37 feet the yield increased to 15 gpm and at 51 feet the yield increased to 19 gpm. At a depth of 58 feet bubbling air was observed at more than 30 spots in the streambed. At a depth of 77 feet enough air was escaping to retard circulation. The hole was reamed and cased to 19 feet but bubbling continued after the tools passed the 36-37-foot zone. The hole was reamed and cased to 42 feet and the connection to the stream was eliminated. Casing off the shallow water lowered the yield to 8 gpm but the production rose to 10 gpm gradually as the hole was deepened to 120 feet.

The yield and analyses indicate that this will be a useful production well.

TABLE 1

RECORD OF WELLS (Continued)

Site 17

Grumbine Property

Completion Data:

Depth - 70 feet, Yield - 80 gpm, As - 297 ppm
Drilling started noon 12/6/66, completed 3:30 p.m. 12/6/66
Average drilling speed - 20 feet/hour
Casing - 14 feet of 6-inch

Geologic Log:

0 - 9 Soil, clay and sand and boulders
9 - 70 Limestone, dolomitic, light gray, water-bearing fractures at 21, 31-32, and 58 feet.

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
21	1.2	526
38	24	309
50	24	273
70	80	297

Remarks:

Water production began at 21 feet and major water-producing zones were encountered at 31-32 and 58 feet.

Yield and analyses indicate that this will be a useful production well.

TABLE 1 (17-A)

RECORD OF WELLS (Continued)

Site 17-A

Winthrop Property

Completion Data:

Depth - 60 feet, Yield - 12 gpm, As - 37 ppm
Drilling started 8:30 a.m. 12/16/66, completed 1:30 p.m. 12/16/66
Average drilling speed - 12 feet/hour
Casing - 20 feet of 6-inch

Geologic Log:

0 - 18	Soil and clay, brown, with boulders
18 - 60	Limestone, dolomitic, gray, with weathered zones, weathered fractures at 23 and 32 feet

Conditions Observed During Drilling:

Depth (ft)	Yield (gpm)	As (ppm)
20	4	0.5
25	8	1.6
60	12	37

Remarks:

Well produced 4 gpm at top of bedrock and then increased in yield at 23 and 32 feet.

This well was intended as an observation well but experience may indicate that it should eventually be used as a production well.